Task#85364

Given that the spacing of the lines in the microwave spectrum of 27Al1H is 1. Calculate the moment of inertia and bond length of–constant at 12.60 cm^{-1} the molecule.

Solution: The energy expression of rotational level is given by(E)=$\frac{J(J+1)h2}{8\pi\times\pi\times I}$;

Selection rule for rotational transition is ΔJ=±1 ;

The energy gap between two successive rotational level (ΔE) is given by

ΔE =$\frac{[(J+1)(J+2)-J(J+1)]h2}{8\pi\times\pi\times I}$, ΔE=$\frac{[J\times J+3J+2-J\times J+J]h2}{8\pi\times\pi\times I}$; ΔE=$\frac{2(J+1)h2}{8\pi\times\pi\times I}$; ; $\frac{;\Delta E}{hC}$=$\frac{2(J+1)h}{8\pi\times\pi\times I\times C}$;
$\frac{1}{\lambda} = \frac{2(J+1)h}{8\pi\times\pi\times I\times C}$ ....(1) ;

For J: 1→0 rotational level transition J=0 in equation (1)

Let, B=$\frac{h}{8\pi\times\pi\times I\times C}$, $\frac{1}{\lambda}$=2B,

So, energy gap between two successive rotation levels=2B=12.60cm^{-1},planck's constant=6.627×10^{-27} erg.s, I=moment of inertia of the molecule. Where, I=μr^2,r=bond length of 27Al1H .

,B=$\frac{h}{8\pi\times\pi\times I\times C}$=6.30 cm^{-1}; I= $\frac{6.627\times10\text{^}-27}{6.30\times8\pi\times\pi\times3\times10\text{^}10}$; I= 4.4× 10^{-40} gm.cm^2

Reduce mass of $^{27}Al^{1}H(\mu)$ = $\frac{M(27Al)\times M(1H)}{M(27Al)+M(1H)}$= $\frac{(\frac{27}{N})\times(\frac{1}{N})}{\frac{27}{N}+\frac{1}{N}}$=$\frac{27}{6.023\times10\text{^}23\times28}$ = 1.6 × 10^{-24}gm;

Where, N= Avogadro's number, M(27Al)= Mass of an ^{27}Al atom,

I=μr^2 ,r=$(I/\mu)^{1/2}$= $\frac{4.4\times 10-40}{1.6\times 10-24}$ = 1.6576X 10^{-8} cm =1.6576 A^0

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